

## Genetics of Fat Colour in Cattle.

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### SUMMARY

Fat colour score (FCS),  $\beta$ -carotene concentration and their relationship were examined in carcasses of Jersey, Limousin, and F1 heifers and in biopsy samples of Jersey, 3/4 Jersey, and 3/4 Limousin weaners. Results demonstrate significant differences between all breeds in  $\beta$ -carotene concentration and FCS. High correlations between FCS and  $\beta$ -carotene concentration were also demonstrated. Sex differences in FCS and  $\beta$ -carotene concentration were not significant. The shape of the distributions of  $\beta$ -carotene content in fat varied between the breeds. High outliers were observed for the pure Jersey, 3/4 Jersey, and F1, and not observed in Limousin and 3/4 Limousin. Based on this preliminary data, we confirmed that  $\beta$ -carotene concentration in fat of cattle has a genetic basis and hypothesise that a major gene(s) may be involved.

**Keywords:** fat colour, cattle, gene,  $\beta$ -carotene

### INTRODUCTION

Carotenoids are a group of hydrocarbons which cause the yellow colouration of fat when they are deposited in the adipose tissue of mammals.  $\beta$ -Carotene is the main carotenoid associated with yellow fat in cattle (Zhou et al. 1993). Excessively pigmented carcasses are not desirable and are downgraded or rejected from domestic and overseas markets. To reduce the incidence of yellow coloured carcasses, cattle are fed a high grain diet which is poor in carotenoid content. However, there are breed differences in the deposition of  $\beta$ -carotene, and consequently, different breeds require various lengths of time on a grain diet to reduce the yellow fat colour. Moreover, some individual animals, even after a long period of time on a grain diet, still have yellow fat (Strachan et al. 1993). Yellow fat also occurs in sheep and appears to be due to a single autosomal recessive gene (Baker et al. 1985). The between and within breed differences in cattle also suggest a genetic basis of fat colour in cattle. The aim of the study was to investigate the genetics of  $\beta$ -carotene deposition in adipose tissue of pure breed, crossbreed, and backcross cattle.

### MATERIALS AND METHODS

**Animal and management.** Pure Jersey (J) and Limousin (L) cows representing genotypes from over 70 sire lines in each breed were used for this study. The animals were a part of the J.S. Davies Cattle Gene Mapping Herd maintained at Martindale, South Australia. The cows were mated with 2 Jersey and 2 Limousin bulls. Pure Jersey, pure Limousin, and F1 (LJ) progeny (born in 1995) were maintained under the same management and grazed the same pastures. The female progeny were slaughtered at 450 days of age after 60 days on feedlot. The same cows were mated with 4 F1 and 2 pure Jersey bulls to produce pure Jersey, 3/4 Jersey, and 3/4 Limousin calves (born in 1996).

**Sample collection, preparation and analyses.** Adipose tissue samples from carcasses of J, L, and LJ heifers were collected on the day of slaughter from the chiller. Subcutaneous fat from the eye muscle area was placed in the plastic vials and stored in -20°C under N<sub>2</sub> gas. Biopsy fat samples from J, 3/4J, and 3/4L weaners were collected from the base of the tail and processed as described by Malau-Aduli *et al* (1995) except that tissue was removed with use of a scalpel. B-Carotene content in the fat samples was analysed as described by Kruk *et al* (1997). Fat colour score (FCS) on carcasses was assessed in the chiller according to AUS-MEAT specifications. Fat colour score of adipose biopsy samples was estimated on a 5-point scale (1-white to 5-very yellow) immediately after removing the fat from biopsy site and rinsing with water.

**Statistical analyses.** Least squares analysis of variance was carried out separately for carcass and biopsy samples using Proc GLM (SAS 1989). The model included the fixed effects of breed, sex, sire and the interactions between breed and sex and breed and sire. The breed by sex and breed by sire interactions were not significant and were removed from the model. Least squares means and differences between means were computed. Residual correlations between  $\beta$ -carotene and fat colour score were computed using Proc CORR (SAS 1989) after adjusting for the effects of breed, sex, and sire.

## RESULTS

**Fat colour score and  $\beta$ -carotene.** Subjectively estimated fat colour scores on carcass and biopsy fat samples were highly correlated with B-carotene concentration in fat ( $r=0.51$  and  $r=0.70$ , respectively). This correlation was higher when estimated on fresh adipose tissue (biopsy samples) than on intermuscular fat derived from chilled carcasses.

**Table 1. Breed least squares means for  $\beta$ -carotene concentration in fat and FCS**

Carcass breed	No	FCS	$\beta$ -carotene	$\beta$ -carotene breed differences		
				JJJJ	LLJJ	LLLL
JJJJ	15	0.71 $\pm$ 0.22	1.77 $\pm$ 0.11	-	*	***
LLJJ	16	0.06 $\pm$ 0.22	1.39 $\pm$ 0.11		-	**
LLLL	24	0.00 $\pm$ 0.17	0.93 $\pm$ 0.09			
Biopsy breed				JJJJ	JJJL	LLLJ
JJJJ	29	2.89 $\pm$ 0.15	1.46 $\pm$ 0.09	-	***	***
JJJL	5	2.18 $\pm$ 0.12	1.00 $\pm$ 0.07			**
LLLJ	49	1.67 $\pm$ 0.12	0.72 $\pm$ 0.08			

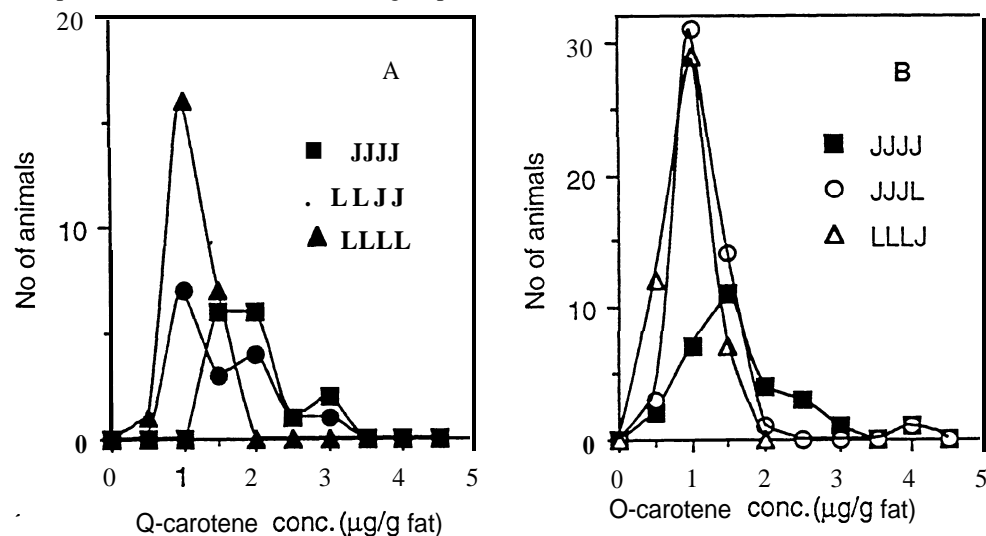
Note: \*\*\*P<0.001, \*\*P<0.01, \*P<0.05, JJJJ=pure Jersey, LLJJ=F1, LLLL=pure Limousin, JJJL=3/4 Jersey, LLLJ=3/4 Limousin.

**Fat colour score,  $\beta$ -carotene and breed.** The breed means for B-carotene concentration in fat and FCS are shown in Table 1. The pure Jersey had the highest concentration of  $\beta$ -carotene in fat in both years. In carcass samples, the difference was significant between pure Jersey and F1 crosses (P<0.05) and between pure Jersey and pure Limousin (P<0.001). The F1 crosses were intermediate in concentration of  $\beta$ -carotene in fat. The differences in biopsy samples between pure Jersey and 3/4 Jersey and between pure Jersey and 3/4 Limousin were highly significant

( $P<0.001$  and  $P<0.001$ , respectively). In the carcass samples (data not presented here), the FCS of the Jersey heifers differed from F1 crosses and the pure Limousin heifers ( $P<0.05$  and  $P<0.01$ , respectively). However, the difference between the F1 and the pure Limousin heifers was not significant. In biopsy samples, the breed differences in FCS followed the same pattern as observed for  $\beta$ -carotene concentration.

**R-Carotene, sex and sire.** Sex did not influence l-carotene concentration in adipose tissue as there was no significant difference between male and female weaners ( $1.1 \pm 0.06$  and  $1.02 \pm 0.07$ , respectively). In the carcass samples, there were no significant differences between the Limousin sires mated to either Jersey or Limousin cows. The Jersey sires 77 and 78 did differ when mated to pure Jersey cows ( $P<0.05$ ). However, this difference between the Jersey sires was not observed in the biopsy samples. The F1 sires mated to Limousin cows to produce 3/4 Limousin progeny did not differ. On the other hand, one F1 sire mated with Jersey cows was significantly different from the other ( $P<0.01$ ).

**$\beta$ -Carotene breed distribution.** The distributions for  $\beta$ -carotene concentration in fat of different breeds are presented in Figure 1 A and 1B. For the pure Jersey and Jersey crosses there are some high  $\beta$ -carotene values which make the distributions broad, skewed right and irregularly shaped. For the pure Limousin and 3/4 Limousin cattle, the distributions are compact, smooth and all values are grouped around the mean.



**Figure 1. Distributions of  $\beta$ -carotene concentration in fat. (A) Carcass samples from pure Jersey, Limousin and F1 crosses. (B) Biopsy samples from pure Jersey and F1 backcrosses.**

## DISCUSSION

The high correlation between FCS and  $\beta$ -carotene concentration reported herein and by other authors (Zhou *et al.* 1993; Gaunt *et al.* 1994) demonstrate that  $\beta$ -carotene concentration in fat

can be a good predictor of FCS in cattle. The differences between the estimates obtained in our study (carcass vs biopsy) could be due to the grading techniques used in biopsy and carcass samples, the sample site, assessor's skills, or physical environment (Gunt et al. 1994).

Breed differences between Jersey and Limousin cattle in  $\beta$ -carotene concentration in adipose tissue and fat colour have been presented elsewhere (Pitchford et al. 1996; Kruk et al. 1997). Morgan et al (1969) also reported that Jersey F1 crosses were intermediate in fat colour. However, there are no such reports about backcross performance. Our study showed that the difference between Jersey, 3/4 Jersey and 3/4 Limousin in  $\beta$ -carotene concentration in fat were significant.

The distributions of  $\beta$ -carotene concentration differed between the breeds. Pure Limousin and 3/4 Limousin had almost symmetric and uniform distributions whereas pure Jersey, 3/4 Jersey, F1 were "tailed" with irregular bumps. In spite of significant differences between some sires, the progeny with extremely high concentration of  $\beta$ -carotene in fat derived mostly from different sires. Such fat samples were re-analysed and the results were confirmed with FCS. The test for distribution normality was performed on this set of data but not discussed here as the number of animals with a high concentration of  $\beta$ -carotene was not sufficient.

Given that the animals in this study were from the same environment, the trends demonstrated from this preliminary data confirm a genetic basis for fat colour. The similarity between the distributions of Jersey, 3/4 Jersey and F1 cattle suggests that there may be a major gene(s) involved in the incidence of higher accumulation of  $\beta$ -carotene in fat. The Jersey, 3/4 Jersey, and F1 cattle may be homozygous or heterozygous for a yellow fat allele(s). On the other hand, the majority of pure Limousin and 3/4 Limousin would not be carrying this allele(s) and consequently, have white fat.

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